SANTA BARBARA CITY CREEKS BIOASSESSMENT PROGRAM
2005 ANNUAL REPORT

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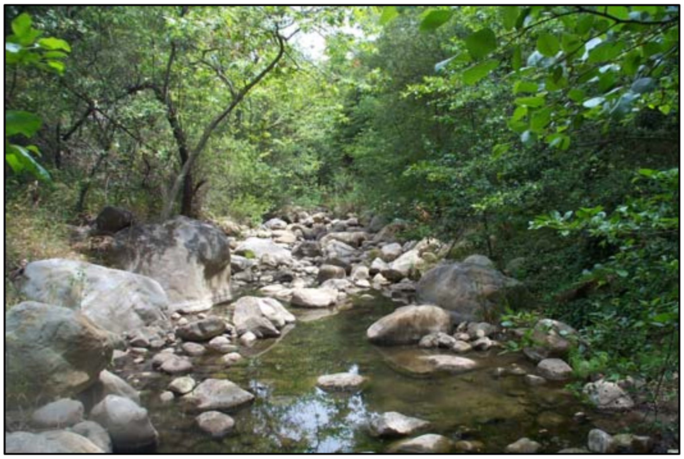

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Executive Summary

Introduction

This report summarizes the results of the 2005 Santa Barbara City Creeks Bioassessment Program. The Program was initiated in 2000 to assess and monitor the "biological integrity" of local creeks as they respond through time to natural and human influences. The Program involves annual collection and analysis of benthic macroinvertebrate (BMI) samples and other pertinent physiochemical and biological data in study creek reaches using USEPA endorsed rapid bioassessment techniques. BMI samples are analyzed in the laboratory, and six "core metrics" specified in the *Index of Biotic Integrity (IBI) for Southern Santa Barbara County Streams* are calculated for each study reach. The IBI provides a measurement of biological integrity for study streams based on the evaluation of the core metrics, which reflect different aspects of the BMI community including diversity, composition, and trophic structure.

Study Area

The study area encompasses eight study reaches in the Mission Creek, Sycamore Creek, and Arroyo Burro watersheds.

Methods

Physiochemical and biological data for the study reaches was gathered through field surveys and laboratory analyses. The six IBI core metrics were calculated for each study reach, and IBI scores and classifications of biological integrity were determined.

Results and Discussion

There were notable differences in BMI community composition in this year's samples, namely lower BMI density, lower insect family diversity, lower percentage of non-insects and Dipterans (particularly Chironomidae), and higher percentage of Baetidae. These changes were presumably due to scouring effects from unusually high storm flows in local creeks this past winter. The changes in BMI community composition had an affect on IBI scores, which tended to have less of a spread between less impacted study reaches (i.e., M3 and AB3) and more impacted study reaches (i.e., SY1, SY2, M1, M2, AB1, and AB2) compared to previous years. However, the classifications of biological integrity produced by the IBI were generally consistent with the ranges established for each study reach in previous years. The only study reaches given new classifications of biological integrity this year were SY1, which was classified at the bottom end of Fair compared to Very Poor to Poor in previous years, and M2, which was classified as Poor this year compared to Very Poor in all previous years. M2 has been subject to habitat restoration efforts, which may have at least contributed to the perceived improvement there. The ability of the IBI to classify sites consistently following the scouring creek flows of this year indicates its utility even with major environmental fluctuations.

Recommendations

Continued study is needed to monitor the biological integrity of local creeks, and help determine the effectiveness of creek restoration efforts. The combined bioassessment efforts of the City and County provide a good data set including creeks with a full range of stressors and impact intensity, so additional study reaches are not necessary at this time. After perhaps two to three years of additional study, the IBI scoring system should be revisited and refined in light of the additional data collected.

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I. Introduction

This report summarizes the results of the 2005 Santa Barbara City Creeks Bioassessment Program. The Program was initiated in 2000 to assess and monitor the "biological integrity" of local creeks as they respond through time to natural and human influences. Karr and Dudley (1981) defined "biological integrity" as "the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region." (Miller et al., 1988). "Bioassessment" is the science of using biological assemblages such as benthic macroinvertebrates, fish, amphibians, diatoms, etc. to assess and monitor the biological integrity of aquatic ecosystems. The logic behind bioassessment is that because different aquatic species have varying habitat requirements and abilities to withstand water pollution and other forms of habitat degradation, one can assess the overall condition of a water body based on which species are living there. Beyond individual species, measurements or "metrics" of biological community structure relating to abundance, diversity, and composition have proven to be reliable indicators of biological integrity (Rosenberg and Resh, 1993, Barbour et al., 1999).

The City's Program involves annual collection and analysis of benthic macroinvertebrate (BMI) samples and other pertinent physiochemical and biological data in study creek reaches using U.S. Environmental Protection Agency (USEPA) endorsed rapid bioassessment techniques. BMI samples are analyzed in the laboratory, and six "core metrics" specified in the Index of Biotic Integrity (IBI) for Southern Santa Barbara County Streams are calculated for each study reach. The IBI provides a measurement of biological integrity for study streams based on the evaluation of six the core metrics, all of which reflect different aspects of the BMI community including diversity, composition, and trophic structure.

The IBI was developed by analyzing data from more than 40 creeks in coastal southern Santa Barbara County that were studied over a four year period from 2000 to 2003. Collectively, the data set encompasses creeks with a wide range of physiochemical conditions, from steep mountain tributaries to wide lowland streams, and degree of impairment, from nearly pristine creeks to those that are highly impacted by human uses. Development of the IBI was funded in a joint effort by the County of Santa Barbara and the City of Santa Barbara. Development of the IBI is further discussed in *Santa Barbara County Creeks Bioassessment Program, 2003 Annual Report and Index of Biological Integrity* (Ecology Consultants, Inc. 2004).

II. Study Area

The study area encompasses eight study reaches in the Mission Creek, Sycamore Creek, and Arroyo Burro watersheds. Study reach locations are shown in Figure 1, and listed in Table 1.

Table 1
Study Reaches

Study Reach	Location
SY1	Sycamore Creek just downstream of Mason Street bridge
SY2	Sycamore Creek below Highway 192 crossing and Coyote Creek/Sycamore Creek confluence
M1	Mission Creek just downstream of De la Guerra Street
M2	Old Mission Creek at Bohnet Park
M3	Mission Creek at upstream end of Rocky Nook Park
AB1	Arroyo Burro just upstream of Alan Road
AB2	Arroyo Burro just downstream of Torino Road
AB3	San Roque Creek (Arroyo Burro tributary) ¼-mile upstream of Foothill Road

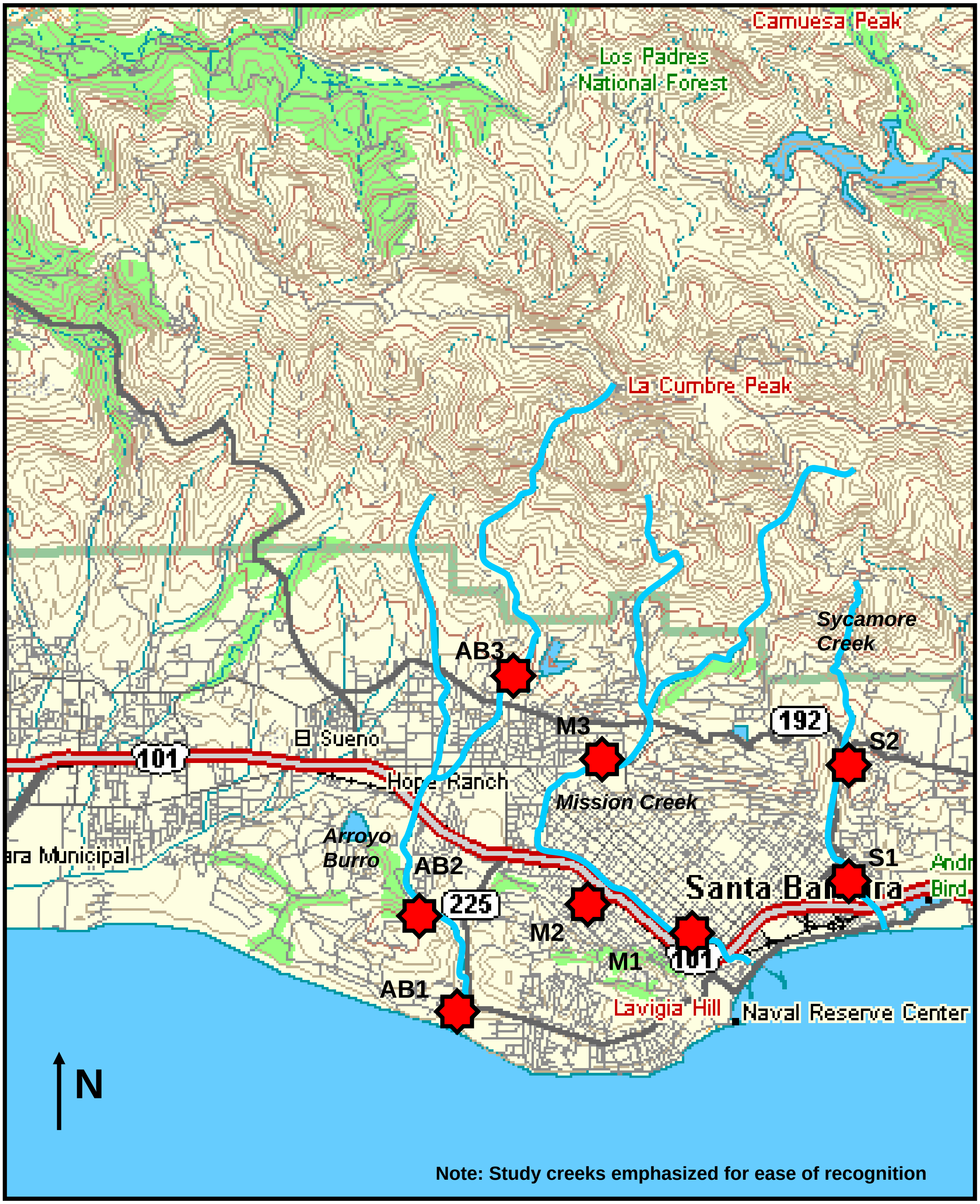
III. Methods

Physiochemical and biological data for the study reaches was gathered through a combination of field surveys and laboratory analyses. Table 2 lists physiochemical and biological parameters determined for each study reach, parameter abbreviations used throughout the remainder of the report, and the method of calculation (e.g., lab or field).

Table 2
List of Parameters Calculated for Each Study Reach

Parameters	Units of Measurement	Method of Calculation
PHYSICAL PARAMETERS		
Wet stream width	Ft.	Field
Channel bottom width	Ft.	Field
Bank full width	Ft.	Field
Habitat assessment score	None	Field
WATER CHEMISTRY PARAMETERS		
Stream temperature	Degrees Fahrenheit (°F)	Field
pH	None	Field
Dissolved oxygen concentration	Milligrams per liter (mg/l)	Field
Conductivity	Microsiemens (µS)	Field
Specific conductance (corrected to 25° Celsius)	µS	Field
BIOLOGICAL PARAMETERS		
BMI density	# per sq. meter ($\#/m^2$)	Field/lab
Insect family diversity	NA	Field/lab
Percent Ephemeroptera/Plecoptera/Tricoptera (EPT)	NA	Field/lab
Biotic index score	NA	Field/lab
Percent sensitive BMIs	NA	Field/lab
Percent non-insects + Diptera	NA	Field/lab
Percent predators + shredders	NA	Field/lab
Native aquatic vertebrate diversity	NA	Field
Percent riparian canopy cover	NA	Field

FIGURE 1: STUDY REACHES



A. Field Surveys

As in previous years of the bioassessment program, field surveys were conducted in the spring during base stream flow conditions (i.e., low flows). The sampling was conducted on May 24, 25, and 26 by Ecology and City of Santa Barbara staff. Sampling in the spring during base flow conditions provides consistency in the sampling from year to year, as the local stream biota is known to undergo seasonal succession (Cooper et al., 1986). The following was completed during each field survey:

- General observations were recorded on a standardized field data sheet, including location, date, time, weather, stream flow conditions, water clarity, and human impacts.
- A 100-meter study reach was delineated along the stream. Stream habitat units (i.e., riffles, runs, pools, etc.) within the study reach were mapped and quantified as a percentage of the total reach length.
- Stream widths (wetted perimeter, channel bottom, and bank full) were measured at three transects in the study reach. Wetted perimeter width is defined as the cross-sectional distance of streambed that is inundated with surface water. Channel bottom width is defined as the cross-sectional distance between the bottoms of the stream banks. Bank full width is defined as the distance from the ordinary high water mark from one stream bank to the other, as evidenced by visible signs of stream flow such as water marks, stream-carried deposits of sediments and debris, and scour features.
- Riparian canopy cover was estimated at the three transects using a spherical densitometer.
- Plant and wildlife species observed in the creek and riparian zone were noted.
- Water temperature, specific conductance, pH, and dissolved oxygen concentration were measured in the field using YSI and Oakton handheld meters. Two measurements of each parameter were made, one in a riffle and the other in a pool, and the two values were averaged.
- BMI samples were collected using a standardized method based on the "multi-habitat" approach described in the USEPA's *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers* (Barbour et al., 1999). Three samples were collected per study reach: one sample from the downstream third of the reach, one from the middle third, and one from the upstream third. Each sample represents approximately one square meter of stream bottom, collected from 10 individual, 0.1-square meter locations (approximately 30 centimeters square). The 10 locations that constituted each sample were selected based on the relative area each stream habitat (i.e., riffles, pools, falls, etc.) covered in the section of stream sampled. For example, if a given stream reach contained approximately 50 percent riffles and 50 percent pools, five locations in riffles and five in pools were selected and sampled. Samples were collected using a D-frame net with 500 μm mesh. In locations with flowing water (e.g., riffles and runs), the net was held upright against the stream bottom, and substrata immediately upstream within the 0.1-square meter area was scraped and stirred up for approximately 15 seconds using feet and hands. Dislodged BMIs and stream bottom materials were carried into the net by the stream current. In areas with little or no current (e.g., pools), stream bottom material was stirred up by foot, followed by a quick sweep of the net through the water column to capture dislodged BMIs. This was repeated three times in each pool sampling location.

- After each BMI sample was collected, it was rinsed with water in a 500 μm sieve to wash out fine sediments, transferred to a plastic container, and preserved in 70 percent ethanol for laboratory analysis.
- A semi-quantitative stream habitat assessment was conducted using the protocol provided in the USEPA's *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers*. Per this protocol, habitat components were visually assessed and scored, including stream substrate/cover, sediment embeddedness, stream velocity/depth regime, sediment deposition, channel flow status, human alteration, channel sinuosity, habitat complexity/variability, bank stability, vegetative protection, and width and composition of riparian vegetation. Each study reach was assigned a total score of between zero and 200 based on the sum of scores assigned to each habitat component. Criteria from the USEPA protocol were used to guide the scoring.
- Quality control measures were incorporated into the field surveys to insure accurate and consistent data gathering. Water monitoring equipment was calibrated regularly. Field crew members were trained to properly operate equipment, take measurements, collect BMI samples, and conduct stream habitat assessments. Stream habitat assessment scoring was done as a group by the field crew.

B. Laboratory Analysis

BMI samples were processed in the laboratory to determine BMI community composition (i.e., taxa present and relative abundance) and overall density. Each BMI sample was strained through a 500-μm mesh sieve and washed with water to remove ethanol and fine sediments. The sample was placed in a plastic tray marked with equally-sized squares in a grid pattern. The entire sample was spread out evenly across the squares. Squares of material were randomly selected, and sorted one at a time under a dissecting microscope until a specified number of BMIs were located and picked out. The proportion of the sample sorted was noted. 110 specimens were picked out from each sample (i.e., three samples, 330 BMIs per study reach). 100 of the 110 BMIs picked from each sample (300 total per study reach) were randomly selected for identification. BMIs were identified using standard taxonomic keys. Insect taxa were identified to the family level. Non-insect taxa (e.g., oligochaetes, crustaceans, etc.) were identified to order or class. After processing and identification, sorted BMIs and sample remnants were bottled separately in 70 percent ethanol for storage.

Quality control measures were incorporated into the laboratory analysis to insure random selection and accurate enumeration and identification of BMIs. BMI sample processing methods were clearly established and strictly followed. All BMI identifications were made by Ecology's Senior Taxonomist, who has five years of experience identifying the local BMIs.

C. Calculation of Core Metrics

The six IBI core metrics were calculated for each sample and study reach to reflect different aspects of BMI community structure including diversity, composition, trophic group representation, and sensitivity to human disturbance.

Insect family diversity was determined by summing the number of insect families found in the sample.

Percent non-insects + Diptera was determined by summing the individual non-insect BMIs and those from the insect order Diptera, dividing by the total number of BMIs in the sample, and multiplying by 100.

Percent EPT was determined by summing individuals from the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Tricoptera (caddisflies), dividing by the total number of BMIs in the sample, and multiplying by 100. Most EPT taxa are sensitive to human disturbance.

Biotic index score and **percent sensitive BMIs** were calculated using disturbance tolerance values for individual BMI taxa provided in CDFG's *List of Californian Macroinvertebrate Taxa and Standard Taxonomic Effort* (2002). This document assigns individual BMI taxa with tolerance values of between 0 and 10 based on their perceived ability to withstand human disturbance. A tolerance value of 0 indicates that a BMI is extremely intolerant of human disturbance, with increasing scores indicating greater tolerances to human disturbance. **Biotic index score** was determined by summing the tolerance values of all the individual BMIs in the sample, and dividing by the total number of BMIs in the sample. **Percent sensitive BMIs** was determined by summing the individuals with a tolerance value of two (2) or less, dividing by the total number of BMIs in the sample, and multiplying by 100.

Percent predators + shredders was determined by summing individual BMIs with predator or shedder functional feeding group designations, dividing by the total number of BMIs in the sample, and multiplying by 100. Functional feeding group designations were obtained from *An Introduction to the Aquatic Insects of North America* (Merritt and Cummins, 1996).

Although it is not one of the IBI core metrics, **BMI density** was determined by multiplying the number of BMIs picked by the proportion of the one square meter sampling area sorted through.

IV. IBI Scoring Ranges and Criteria

The IBI provides scoring ranges of between 2 and 10 for each of the six core metrics (see Table 3). For core metrics that decrease with increasing human disturbance (e.g., # insect families), higher values corresponded with higher scores. For core metrics that increase with increasing human disturbance (e.g., biotic index score), lower values corresponded with higher scores.

Table 3: Core Metric Scoring Ranges

Score	# Insect Families	% EPT	Biotic Index Score	% Sensitive BMIs	% Non-Insects + Diptera	% Shredders + Predators
10 (Excellent)	≥26	≥55	≤4.00	≥28	≤30	≥22
8 (Good)	20-25	41-55	4.01-4.74	21-27	31-47	16-21
6 (Fair)	13-19	28-40	4.75-5.48	14-20	48-63	11-15
4 (Poor)	7-12	14-27	5.49-6.22	7-13	64-80	5-10
2 (Very Poor)	≤6	≤13	≥6.23	≤6	≥81	≤4

Individual scores for the six core metrics are summed to provide a total score of between 12 and 60 for the study reach. The IBI provides classifications of biological integrity (i.e., Excellent, Good, Fair, Poor, and Very Poor) based on the total score. IBI classifications and scoring ranges are provided in Table 4.

Table 4: Classifications of Biological Integrity and Scoring Ranges	
Category	**Score Range**
Excellent	54-60
Good	48-53
Fair	36-47
Poor	24-35
Very Poor	12-23

V. Results

A. Physiochemical Data

Table 5 provides physiochemical data for the individual study reaches collected this year, and ranges in values collected in this and previous years of study. Mean values and ranges among all the study reaches for this year are provided at the bottom of the table.

B. Biological Data

Table A-1 provides a list of the plant species observed at the study reaches. The table also indicates the number of native and introduced plant species observed at each study reach, and the percentage of plant species observed that are native. The number of years each study reach has been surveyed is provided at the top of the table. Plant observations from multiple years are combined in the table.

Table A-2 provides a list of vertebrate species observed at the study reaches. The number of years each study reach has been surveyed is provided at the top of the table. Vertebrate species observations from multiple years are combined in the table.

Table A-3 lists BMI taxa and breaks down their occurrence and abundance by sample and study reach for 2005. Core metric values are also provided in the table. Although not a core metric, BMI density is also provided. Over the years, insect taxa have composed the vast majority (about 95 percent) of BMIs found in the samples from local creeks. Common aquatic insect orders found in local creeks include Ephemeroptera (mayflies), Plecoptera (stoneflies), Tricoptera (caddisflies), Coleoptera (beetles), Diptera (true flies), Hemiptera (true bugs), Odonata (dragonflies and damselflies), and Megaloptera (dobson flies and alder flies). Non-insects found over the years include Gastropoda (snails); several types of crustaceans including Ostracoda, Copepoda, Decapoda, Amphipoda, and Isopoda; Acari (water mites); Turbellaria (flatworms); Oligochaeta (segmented worms); Hirudinea (leeches); and Nematomorpha (horsehair worms).

Table 5 Physiochemical Data										
Study Reach	# years surveyed	Year	Wet stream width (ft.)	Habitat Assessment Score	Stream temp. (°F)	pH	Dissolved Oxygen (mg/l)	Conduct. (µS)	Specific Conduct. (µS at 25°C)	% riparian canopy cover
SY1	4	2005	14.2	110	63.5	8.42	11.74	2388	2791	97
SY1	4	Range	9.4-14.2	84-110	59.2-63.5	8.09-8.51	7.52-11.74	1786-2545	2158-3140	80-97
SY2	3	2005	15.3	116	64.2	8.31	9.40	1594	1846	87
SY2	3	Range	15.3	109-116	57.7-64.2	7.85-8.31	9.12-9.68	1291-1594	1624-1846	72-87
M1	5	2005	18.6	85	73.4	7.96	13.79	1183	1229	43
M1	5	Range	13.1-18.6	80-88	66.7-80.4	7.96-8.20	12.26-15.86	1183-1252	1177-1358	27-43
M2	4	2005	8.8	110	72.3	7.65	10.52	1350	1423	18
M2	4	Range	8.3-8.8	64-110	63.5-72.3	7.65-8.37	4.05-10.52	1172-1350	1364-1423	8 to 68
M3	5	2005	15.9	165	60.3	8.16	9.52	796	969	88
M3	5	Range	12.7-15.9	157-165	60.3-66.6	8.01-8.86	8.14-9.52	796-895	969-1083	73-93
AB1	4	2005	13.1	99	62.4	7.76	8.91	1797	2125	70
AB1	4	Range	13.1-15.4	71-104	61.9-63.3	7.76-8.57	6.86-10.61	1350-1797	1608-2125	40-83
AB2	5	2005	15.3	107	62.4	7.78	8.52	1344	1592	90
AB2	5	Range	8.8-16.5	70-107	56.5-72.3	7.78-8.43	6.84-11.80	838-1580	967-1663	87-90
AB3	5	2005	15.3	174	62.8	8.22	9.59	928	1094	93
AB3	5	Range	9.1-15.3	158-174	56.1-63.5	7.80-8.74	8.51-9.73	789-1097	960-1409	92-93
All	--	*2005 Mean*	*14.6*	*120.8*	*65.2*	*8.0*	*10.2*	*1422.5*	*1633.6*	*73.3*
All	--	*2005 Range*	*8.8-15.9*	*85-174*	*60.3-73.4*	*7.76-8.42*	*8.52-11.74*	*796-2388*	*969-2791*	*18-97*

C. IBI Scores and Classifications

Table 6 lists core metric values, IBI scores, and classifications of biological integrity based on the criteria in Tables 3 and 4.

Table 6 Core Metric Values and IBI Scores														
Study Reach	# insect families		% EPT		biotic index score		% sensitive BMIs		% non-insects + Diptera		% predators +shredders		IBI score	Classification
	Value	*Score*	*Value*	*Score*	*Value*	*Score*	*Value*	*Score*	*Value*	*Score*	*Value*	*Score*		
SY1	13	6	56	10	4.79	6	0	2	37	8	5	4	36	Fair
SY2	6	2	68	10	4.58	8	0	2	28	10	3	2	34	Poor
M1	5	2	29	6	5.41	6	0	2	70	4	1	2	22	Very Poor
M2	6	2	57	10	4.85	6	0	2	43	8	0	2	30	Poor
M3	17	6	58	10	4.65	8	12	4	37	8	8	4	40	Fair
AB1	11	4	62	10	4.78	6	1	2	34	8	3	2	32	Poor
AB2	9	4	53	8	4.94	6	0	2	44	8	1	2	30	Poor
AB3	13	6	61	10	4.64	8	5	2	38	8	5	4	38	Fair
Mean	10	4	56	9	4.80	7	2	2	41	8	3	3	33	*Poor*

Table 7 provides IBI scores for the study reaches since the beginning of the Bioassessment Program in 2000. The table also shows the range of IBI scores and classifications of biological integrity for each study reach in all years of study.

Table 7
IBI Scores and Classifications from 2000 to 2005

Study Reach	IBI Score							Classification Range
	2000	2001	2002	2003	2004*	2005	Range	
SY1	-	-	18	32	24	36	18-36	Very Poor to Fair
SY2	-	-	-	32	26	34	26-34	Poor
M1	14	-	14	14	16	22	14-22	Very Poor
M2	-	-	14	14	16	30	14-30	Very Poor to Poor
M3	50	-	48	42	46	40	40-50	Fair to Good
AB1	-	-	22	26	28	32	22-32	Very Poor to Poor
AB2	26	18	18	24	--	30	18-30	Very Poor to Poor
AB3	44	44	44	36	-	38	36-44	Fair

* IBI scores for 2004 may be slightly different due to the use of alternative BMI sampling methodology by ECORP Consulting, Inc. See the report from ECORP for details (listed in VIII. References).
- = study reach not surveyed in this year.

VI. Discussion

Habitat conditions, biota, and IBI scores and classifications for the study reaches are discussed below. Following the discussions of individual study reaches is an assessment of how overlying factors, namely unusually high rainfall and stream flows this past winter, may have influenced the BMI communities at the study reaches as a whole.

SY1

SY1 is in the urbanized lowland portion of the City, and is tightly abutted by residential uses. The watershed of SY1 is more than 50 percent developed, primarily by suburban residential uses with a small amount of agriculture. Physical habitat conditions at this study reach are less than optimal, as reflected by low physical habitat assessment scores, which ranged from 84 to 95 in previous years, and increased to 110 in 2005. As with most of the other study reaches, habitat assessment score was enhanced this year largely due to noticeably higher stream flows compared to previous years of study. Primary reasons for the generally low habitat assessment scores at this study reach include a narrow riparian corridor (generally 20 feet wide or less), infestation by non-native vegetation (more than 50 percent non-native species, see Table A-1), unstable, eroding creek banks, creek bank alteration (i.e., shoring with rock and concrete), and increased deposition of fine sediments in pools.

Despite the obvious degradation of the creek banks and riparian zone, the creek channel is still in decent condition, with intact cobble substrate in well-developed riffles, and some large, fairly deep pools. While the riparian corridor is very narrow, there are several mature sycamores and oaks, which provide organic material including leaf litter and woody debris to the stream bottom. The mature trees shade the stream bottom, as evidenced by excellent riparian canopy cover, which was 97 percent in 2005 and has been no lower than 80 percent in previous years. Good canopy cover correlates with cool stream temperature (59.2 to 63.5 °F), which is advantageous for several native aquatic invertebrate and vertebrate species. pH and dissolved oxygen concentration have been normal in this creek in 2005 and previous years. As is generally the case with streams having highly developed watersheds, SY1 show signs of water quality impairment in the form of high conductivity and specific conductance, which were 2,388 and 2,791 µS, respectively, in 2005. Conductivity has consistently been highest at SY1 even compared with highly disturbed study reaches in Mission Creek and Arroyo Burro. This probably indicates that mineral concentrations are naturally higher in Sycamore Creek.

This year SY1 had an IBI score of 36 and Fair classification of biological integrity. This was the highest IBI score for this study reach to date. The previous high for this study reach was an IBI score of 32 and Poor classification of biological integrity in 2003. The higher IBI score this year is attributable to (1) higher percent EPT representation, primarily by mayflies of the family Baetidae, and (2) lower percent non-insects + Diptera. These changes in community composition also resulted in lower biotic index score compared to previous years. With the exception of higher stream flow in 2005, habitat conditions did not change noticeably.

SY2

SY2 is upstream of SY1 in a higher gradient stretch of Sycamore Creek. This reach is in a rural residential area, and is tightly abutted by Sycamore Canyon Road on one side and residential development on the other. The watershed of this study reach is less developed than SY1, with lesser coverage by rural residential and agricultural uses. Similar to SY1, habitat degradation is obvious at this site, as reflected by fairly low physical habitat assessment scores (116 in 2005). The creek banks are in some places bare of vegetation and actively eroding. Many of the pools have been almost completely filled with fine sediments, and increased fine sediment deposition is apparent throughout the creek bottom. The riparian zone has been reduced to 15 to 30 feet in width, with impingement from the adjacent road and residences. Non-native vegetation is common (50 percent non-native species, see Table A-1), with large *Eucalyptus* being the dominant canopy trees. The *Eucalyptus* provide shade to the stream bottom (riparian canopy coverage of 87 percent in 2005), but also leaf litter that creates an oily sheen in the water. Stream temperature has been relatively cool (range of 59.2 to 63.5 °F over three years), and pH and dissolved oxygen concentration have appeared normal. Conductivity (1,291 to 1,594 µS) and specific conductance (1,624 to 1,846 µS) have been high compared to other creeks, but not as high as in SY1 downstream.

This year SY2 had an IBI score of 34 and Poor classification of biological integrity. This was the highest IBI score for this study reach to date. The previous high for this study reach was an IBI score of 32 in 2003. Like SY1, SY2 had higher percent EPT due to increased Baetidae, lower percent non-insects + Diptera, and lower biotic index score that in previous years. Insect family diversity was also lower than in previous years at SY2. With the exception of higher stream flow in 2005, habitat conditions did not change noticeably at this site.

M1

The lower reach of Mission Creek is in the highly urbanized downtown area, is tightly abutted by dense residential development on both sides, and has been largely channelized with concrete vertical banks. The upstream watershed of this study reach is approximately 50 percent developed, mostly by residential and commercial uses. Physical habitat assessment scores have been very low at this site, ranging from 80 to 88 in five years of study. The riparian corridor has been almost completely destroyed in this reach due to the construction of concrete banks and adjacent homes. A few mature sycamore trees remain, with ground being mostly bare or covered with non-native weedy vegetation. Native plant species account for only 46 percent of those identified at this study reach. Riparian canopy coverage is sparse (27 to 43 percent in five years of study). Greater solar input causes higher stream temperatures (66.7 to 80.4 °F) compared to other local creeks. Dissolved oxygen concentration is high (12.26 to 15.86 mg/l) during daylight hours due to increased algal activity. pH has appeared normal. Conductivity (1,183 to 1,252 μS) and specific conductance (1,177 to 1,358 μS) have been elevated compared to upstream in the watershed (i.e., at M3).

This year M1 had an IBI score of 22 and Very Poor classification of biological integrity. This was the highest IBI score for this study reach to date. The previous high for this study reach was an IBI score of 16 in 2003. As in previous years, this site was characterized by very low insect family diversity and a near absence of sensitive BMIs and predators + shredders. Percent EPT and biotic index score were slightly improved this year, primarily due to increased representation by Baetidae and fewer non-insects.

M2

M2 is in the old channel of Mission Creek in an urbanized area of the City, and is surrounded by residential and institutional land uses. This section of the old Mission Creek channel no longer receives flows from the majority of the watershed, which have been diverted to a concrete flood channel aligned along Highway 101. The area M2 receives flows from is only about 600 acres, and is more than 75 percent urbanized.

Between the 2003 and 2004 surveys the City implemented a creek restoration project at this site. The creek channel was reshaped in some areas, and a bioswale was created in an effort to cleanse pollutants from urban runoff. Non-native vegetation was cleared, including numerous large *Eucalyptus* trees that once dominated the riparian canopy, and native vegetation was planted. Weeding of non-native vegetation has been ongoing since project implementation.

Physical habitat assessment score improved from 79 in 2003 to 110 in 2005. This improvement is due primarily to the removal of non-native vegetation, establishment of more native vegetation, and stabilization of creek banks resulting from the restoration efforts. Stream bottom habitat was also improved, with more stable cobble and boulder substrate present, and less coverage by fine sediments. Despite these improvements, habitat degradation remains in the form of a narrow riparian corridor (constrained by adjacent school, park, and homes) that still has a high percentage of non-native species, bare, erodable creek banks in some areas, absence of deep pools, and channelization.

Due to the removal of most of the non-native overstory trees, riparian canopy cover was much lower in 2005 (18 percent) compared to 2003 (68 percent), but improved from 2004 (eight percent). The reduced riparian canopy coverage will allow greater solar input until native trees become large enough to provide more shade. Not surprisingly, stream temperature was higher in 2005 (72.3 °F) compared to previous years. Dissolved oxygen concentration and pH appeared normal in 2005. Conductivity (1,350 μS) and specific conductance (1,423 μS) were moderately high in 2005 as in previous years, reflecting pollution inputs from urban uses.

This year M2 had an IBI score of 30 and Poor classification of biological integrity. This represents a near doubling in IBI score and raise in classification compared previous years, when the IBI score ranged from 14 to 16. As in previous years, M2 had low insect family diversity and an absence of sensitive BMIs and predators + shredders in 2005. However, percent EPT was much higher than in previous years due to greatly increased numbers of Baetidae, and percent non-insects + Diptera and biotic index score were much lower compared to previous years. At this point, it is not clear whether these changes in BMI community composition can be attributed more to the recent habitat restoration efforts, or to high rainfall and scouring creek flows last winter (see "Overall Trends" discussion below).

M3

M3 is upstream of M1 and M2 in a high gradient stretch of Mission Creek. This reach is bordered by Rocky Nook Park on one side, and a natural slope vegetated with a coast live oak forest on the other. The watershed of M3 is much less developed than the downstream study reaches, with approximately 80 percent being natural habitat and 20 percent occupied by low density residential development, roads, and agriculture. There is some visible habitat disturbance at this site in the form of riparian zone impingement by Rocky Nook Park, some non-native vegetation in the riparian understory, minor creek bank instability and minor increases in fine sediment deposition in the creek channel. However, the habitat at M3 is largely intact, as reflected by physical habitat assessment scores that have ranged from 157 to 165. The stream has natural boulder-dominated bed and banks, clean cobble and gravel deposits, well-developed riffles and cascades, deep pools, and abundant leaf litter and woody debris contributed by a mature canopy of native oaks, sycamores, alders, and willows. Native vegetation is dominant in the riparian zone (73 percent), and riparian canopy cover is high (73 to 93 percent in five years of study).

Water quality has been good overall at M3 in the five years of study, with low temperature (60.3 to 66.6 °F), optimal dissolved oxygen levels (8.14 to 9.53 mg/l), normal pH, and lower conductivity (796 to 895 µS) and specific conductance (969 to 1,083 µS) than at downstream reaches. This is the only City study reach where rainbow trout (*Oncorhynchus mykiss*) have been observed in the six years of study. This species is generally sensitive to human disturbance, and an indicator of good habitat conditions.

This year M3 had an IBI score of 40 and Fair classification of biological integrity. In the five years of study IBI score has ranged from 40 to 50 and classification of biological integrity from Fair to Good. The lower IBI score in 2005 compared to previous years can be attributed to lower insect family diversity (even though it was still higher than any other study reach in 2005), and fewer sensitive BMIs and predators + shredders.

AB1

AB1 is in a predominantly suburban area, but is not as tightly abutted by development as are some of the study reaches. The west side of creek is an open space area that is several hundred feet wide. The east side has 150 feet of riparian and upland vegetation, beyond which is Las Positas Road. The watershed of AB1 is approximately 45 percent developed with urban and agricultural uses. Physical habitat conditions at this study reach are generally poor. Physical habitat assessment score was 99 in 2005, and has ranged from 71 to 104. This section of Arroyo Burro is characterized by extremely unstable, actively eroding creek banks, a channel bottom that has down cut as much as 30 feet in some areas, and increased deposition of fine sediments in the creek bottom. The riparian zone is wide in this stretch of the creek and includes many mature willows and coast live oaks. However, riparian habitat has been impacted by trails and human traffic, and has major infestations of non-native vegetation, most noticeably giant reed (*Arundo donax*). Non-natives account for approximately 44 percent of the plant species observed at this site.

Riparian canopy cover was 70 percent in 2005, and has been as high as 83 percent in previous years. Similar to previous years of study, stream temperature was relatively cool in 2005 (62.4

°F). pH and dissolved oxygen concentration were normal in 2005 and previous years. As at the other highly impacted study reaches, AB1 had high conductivity (1,797 µS) and specific conductance (2,125 µS) this year, which were highest levels recorded at this study reach.

This year AB1 had an IBI score of 32 and Poor classification of biological integrity. This was the highest IBI score for this study reach to date. The previous high for this study reach was an IBI score of 28. Like the other study reaches, an increased proportion of Baetidae and decreased representation by non-insects and Diptera improved the score. As in previous years, AB1 had low insect family diversity and few sensitive BMIs, predators, and shredders in 2005.

AB2

Similar to AB1, AB2 is in a predominantly suburban area, but is more tightly abutted by adjacent homes, which sit high on the banks above the severely down cut creek channel. The watershed of AB2 is approximately 40 percent developed with urban and agricultural uses. Physical habitat conditions at this study reach are generally poor. Physical habitat assessment score was 107 in 2005, and has been as low as 70 in previous years. Similar to AB1, AB2 has unstable, actively eroding creek banks, a down cut channel bottom, and increased deposition of fine sediments in the creek bottom. The riparian zone is narrower here, averaging approximately 50 feet in width. Non-native vegetation is prevalent (including giant reed), accounting for approximately 47 percent of the plant species observed. Riparian canopy cover has been consistently high (87 to 90 percent). Stream temperature was cool in 2005 (62.4 °F), and has been somewhat variable in previous years (56.5 to 72.3 °F). pH and dissolved oxygen concentration were normal in 2005 and previous years. Conductivity (1,344 µS) and specific conductance (1,663 µS) were high in 2005, and have been somewhat variable over the years.

This year AB2 had an IBI score of 30 and Poor classification of biological integrity. This was the highest IBI score for this study reach to date. The previous high for this study reach was an IBI score of 26 in 2000, with previous lows of 18 in 2001 and 2002. Like the other study reaches, an increased proportion of Baetidae and decreased representation by non-insect taxa improved the score. As in previous years, AB1 had low insect family diversity and few sensitive BMIs, predators, and shredders in 2005.

AB3

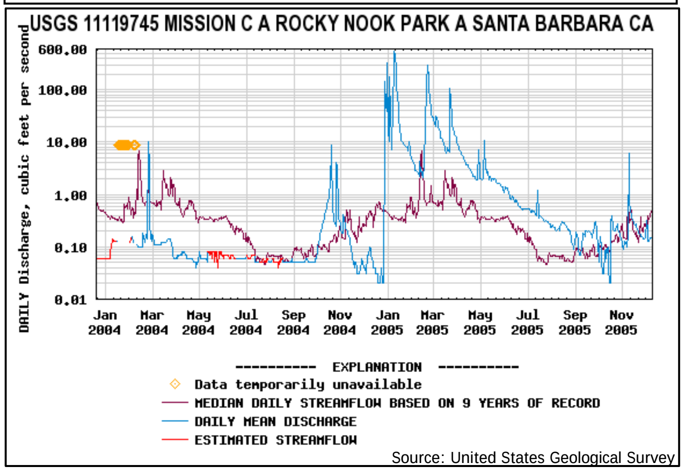
AB3 is located upstream of Foothill Road in San Roque Creek, a major tributary of Arroyo Burro. Similar to M3, AB3 is a higher gradient, fairly intact creek surrounded by natural habitat near the base of the Santa Ynez Mountains. Only about 10 percent of its upstream watershed is developed, mostly by agricultural uses (i.e., orchards). Overall, habitat quality is excellent in AB3, as reflected by consistently favorable physical habitat assessment scores (158 to 174) over the years. The only visible sign of degradation in AB3 is slightly increased fine sediment deposition, presumably originating from upstream orchards. The creek has natural bedrock and boulder-dominated bed and banks, generally clean cobble and gravel deposits, well-developed riffles, deep pools, and abundant leaf litter and woody debris contributed by a mature canopy of native oaks, sycamores, alders, and cottonwoods. Native vegetation composition (86 percent) and riparian canopy cover (92 to 93 percent) have been excellent in this study reach over the years.

Water quality was fair at AB3 in 2005, with low temperature (62.8 °F), optimal dissolved oxygen (8.22 mg/l), normal pH, and moderate conductivity (928 µS) and specific conductance (1,094 µS). While conductance has consistently been much lower in AB3 compared to downstream study reaches in the watershed, it is moderately elevated compared to many nearly pristine creeks in the region (Ecology, 2004). Elevated nitrate levels have also been documented at AB3 (Ecology, 2004). Elevated conductivity and nitrate likely indicate that some water quality impairment exists at AB3, presumably due to runoff from upstream agriculture and rural residences.

This year AB3 had an IBI score of 38 and Fair classification of biological integrity. In five years of study IBI score has ranged from 36 to 44, corresponding to a Fair classification of biological integrity in all years. Although IBI score was within the range of previous years, AB3 had lower insect family diversity (13 families) compared to all previous years (22 to 31 families). Percent EPT was higher this year (61 percent) compared to previous years (38 to 58 percent) due to increased Baetidae.

Overall Trends

Figure 2: Daily Discharge, Mission Creek at USGS Gauging Station in Rocky Nook Park

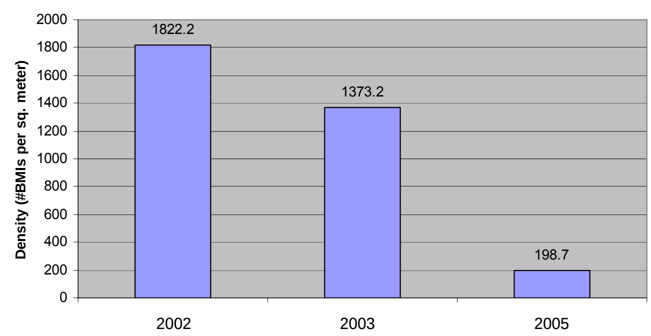


At each of the six highly disturbed study reaches, SY1, SY2, M1, M2, AB1, and AB2, IBI scores were higher this year than in any previous year surveyed. Conversely, the two less impacted study reaches M3 and AB3 had low or near-low IBI scores compared to other years. The result is that there was less spread in IBI scores between highly impacted and less impacted sites compared to in previous years. An overlying cause of this is likely the high stream discharges created this past winter by unusually high rainfall levels. Figure 2 shows daily discharges in 2004 and 2005 at the USGS stream flow gauge in Mission Creek at Rocky Nook Park, contrasting a relatively dry year (2004) with a very wet one (2005). Daily discharge was in excess of 600 cubic feet per second (cfs) following a rainstorm in mid-January of this year. This discharge has been exceeded or equaled only four other times since the Mission Creek gauge was established in December 1983. Five other events between January and March 2005 produced daily discharges in excess of 100 cfs, two of which were over 300 cfs. In contrast, the highest daily discharge in all of 2004 at the Mission Creek gauge was approximately 10 cfs.

Extreme stream flows like those that occurred last winter can drastically alter streambed morphology, scouring out large volumes of stream bottom material and most of the aquatic life (e.g., algae, BMIs, fish, etc.) residing there. BMIs and other aquatic organisms must re-colonize the stream after peak flows subside. It can take a couple of years for the aquatic community to recover to a “normal” state from these types of events. This scouring effect from unusually high stream flows has been observed in Rattlesnake Creek, a tributary of Mission Creek (Cooper et. al., 1986). Since BMI samples were collected in May, or only two months after the last scouring flows occurred, the BMI communities in local creeks had not completely recovered by the time of sampling.

Several trends in the data indicate that BMI communities in the study reaches were still recovering from scouring storm flows at the time of sampling. First, there were far fewer BMIs in the study streams, as indicated by markedly lower BMI density in the samples. Figure 3 shows average BMI density at the seven study reaches (SY1, M1, M2, M3, AB1, AB2, and AB3) that were all surveyed in 2002, 2003, and 2005. As shown, density was much lower in 2005 (198.7 BMIs per m^3) than in 2002 (1,822.2 BMIs per m^3) and 2003 (1,373.2 BMIs per m^3).

Figure 3: Average BMI Density by Year



Second, there were notable changes in BMI community composition. For example, there was a much higher percentage of Baetidae mayflies in the samples in 2005 (49 percent) compared to 2002 (five percent) and 2003 (27 percent). Baetidae, which is one of the most ubiquitous families in local creeks, has also been observed to be one of the quickest to recover in local creeks after scouring storm flow events (Cooper, et. al., 1986). There were also fewer non-insects and Dipterans in the samples in 2005 (43 percent) compared to 2002 (73 percent) and 2003 (65 percent). This was particularly noticeable for the family Chironomidae, which like Baetidae is one of the most ubiquitous BMIs in local creeks. Percent Chironomidae fell to 21 percent in 2005, as compared to 38 percent in 2002 and 2003, respectively. Another sign that local BMI communities were still in a state of recovery at the time of sampling this year was lower average insect family diversity (10.0 families) compared to in 2002 (16.6 families) and 2003 (12.4 families).

In summary, there were notable differences in BMI community composition in this year's samples, namely lower BMI density, lower insect family diversity, a lower percentage of non-insects and Dipterans (particularly Chironomidae), and higher percentage of Baetidae. These changes were presumably due to scouring effects from unusually high storm flows in local creeks this past winter. The changes in BMI community composition had an affect on IBI scores, which tended to have less of a spread between less impacted study reaches (i.e., M3 and AB3) and more impacted study reaches (i.e., SY1, SY2, M1, M2, AB1, and AB2) compared to previous years. However, the classifications of biological integrity produced by the IBI were generally consistent with the ranges established for each study reach in previous years. The only study reaches given new classifications of biological integrity this year were SY1, which was classified at the bottom end of Fair compared to Very Poor to Poor in previous years, and M2, which was classified as Poor this year compared to Very Poor in all previous years. M2 has been subject to habitat restoration efforts, which may have at least contributed to the perceived improvement there. The ability of the IBI to classify sites consistently even following the scouring creek flows of this year indicates its utility even with major environmental fluctuations.

VII. Recommendations

Continued study is needed to monitor the biological integrity of local creeks, and help determine the effectiveness of creek restoration efforts as sites such as M2. The combined bioassessment efforts of the City and County provide a good data set including creeks with full range of stressors (i.e., agricultural, suburban, and urban uses) and impact intensity (i.e., from nearly pristine to highly degraded), so additional study reaches are not necessary at this time. After perhaps two to three years of additional study, the IBI scoring system should be revisited and refined in light of the additional data collected.

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